

## INVESTIGATIONS INTO THE USE OF PHOSPHINE FOR THE QUARANTINE TREATMENT OF PLANT CUTTINGS

Oliver C. Macdonald and Ken. A. Mills  
Central Science Laboratory, UK

Methyl bromide has been used for many years in Europe as a quarantine treatment for a range of pests on live plants, particularly plant cuttings. In the UK, most chrysanthemum cuttings are routinely fumigated on import with  $13.5 \text{ mg.l}^{-1}$  of methyl bromide for 4 hours, in line with a European and Mediterranean Plant Protection Organisation (EPPO) quarantine treatment schedule, originally developed at the Central Science Laboratory (CSL). This treatment has been particularly useful in excluding *Liriomyza* spp. leafminers and a range of lepidopteran pests and, while not officially sanctioned, is also used to treat a wide range of other plants. At the giant flower auction at Aalsmeer in The Netherlands, two fumigation chambers are in almost constant use treating a wide range of produce for export, mostly using a standard  $1\frac{1}{2}$  hour treatment with  $30 \text{ mg.l}^{-1}$  of methyl bromide plus  $0.3 \text{ ml.l}^{-1}$  vapourised dichlorvos.

Any alternative treatment would ideally be another fumigant, on the grounds of efficacy and to allow existing equipment to be used with minimum modification. The only other fumigant currently available in the UK is phosphine. This appears to have previously been discounted for plant quarantine purposes for two reasons. Most importantly, fumigations are generally of long duration, making them unsuitable for perishable commodities such as plant cuttings. This was at least partly due to the time required by conventional solid formulations to release the gas. Recent work at CSL to develop more accurate dosing techniques has led to the development of a cylinder formulation of phosphine which is expected to be registered for use as a pesticide in the UK soon. This will allow rapid dosing of chambers as with methyl bromide. Additionally there seems to have been a belief that phosphine was phytotoxic. There is little valid evidence for this belief however. Hawkes (1973) reported severe damage to chrysanthemum cuttings when fumigated for 48 hours with an estimated phosphine concentration of  $3 \text{ mg.l}^{-1}$ . However this is an unacceptably long treatment for unrooted cuttings and it is also possible that the damage was caused by ammonia released by formulations containing ammonium carbonate or urea rather than by the fumigant itself.

To investigate the potential for the use of phosphine for the treatment of plant cuttings, experiments were carried out on a range of pests and plants. Preliminary tests (Macdonald and Mills, 1994) were promising but showed that relatively high concentrations of phosphine, about  $2 \text{ mg.l}^{-1}$  would be needed if treatments were to be limited to a few hours. Neither chrysanthemum nor poinsettia cuttings treated with  $1 \text{ mg.l}^{-1}$  for up to 36 hours were damaged in these tests.

## Methods

Fumigations were carried out at 15°C in a 1.7 m<sup>3</sup> enamelled steel fumigation chamber. Test organisms were eggs and scales of *Bemisia tabaci* on poinsettia leaves, eggs and larvae of *Liriomyza huidobrensis* in tomato leaves (both of these insects are notifiable organisms in the UK), western flower thrips (*Frankliniella occidentalis*) and adult *Myzus persicae*. In addition, poinsettia cuttings, CV RedSail were treated. Gas, as a 3% w/w mixture in CO<sub>2</sub> was introduced to the chamber and the concentration determined by gas chromatography. The concentration was then adjusted to approximately 2 mg.l<sup>-1</sup> by partial vacuum and dilution before the test organisms were introduced. Samples of the test organisms were removed at intervals between 2 and 36 hours after their introduction. Gas concentrations were monitored at regular intervals throughout the fumigation. In all cases an untreated control sample was also used.

The mortality of insect samples was determined at appropriate intervals, depending on the species and life-cycle stage, after the treatment, and dose response curves calculated by probit analysis. Plant samples were monitored for signs of phytotoxic effects at regular periods up to one month after treatment.

## Results & Discussion

Tables 1 and 2 show the results of experiments on the insects. With an initial dose of 2 mg.l<sup>-1</sup> no insects survived beyond 24 hours, although some eggs of *L. huidobrensis* did hatch after a 24 hours treatment. All *B. tabaci* were killed by treatments longer than 8 hours, with young eggs surviving the longest treatment. No damage was caused to the poinsettias, even after a 25 hour fumigation, although further tests are needed to increase confidence in the results.

The long duration needed to kill *L. huidobrensis* eggs means that fumigation with 2 mg.l<sup>-1</sup> of phosphine is unlikely to be a suitable quarantine treatment for this pest, although an increase in concentration may allow the time to be reduced. The results for *Bemisia tabaci* are far more promising. In the UK the main source of this pest has been imported poinsettia cuttings. Since these suffer unacceptable levels of damage when treated with methyl bromide, there is currently no effective quarantine treatment for this species. An 8 hour fumigation with phosphine, while longer than existing methyl bromide treatments, should be acceptable to the industry.

## Conclusions

Phosphine requires longer fumigations for the complete control of pests on plant cuttings than does methyl bromide. However, while for some pests, such as *L. huidobrensis*, this results in unacceptably long treatments, for other pests such as *B. tabaci* the duration of treatments should be acceptable. Further work may be able to reduce the duration of treatments by using higher doses of phosphine. There also appears to be no detrimental effects to plants caused by phosphine, even with fumigation durations in excess of those needed to control insects. For some purposes therefore, phosphine shows potential for the quarantine treatment of live plants.

Table 1: Response of plant pests to fumigation with phosphine.

Species	Stage	LD <sub>50</sub> (mg.l <sup>-1</sup> h)	LD <sub>99</sub> (mg.l <sup>-1</sup> h)
<i>Bemisia tabaci</i>	Eggs (<3 days old)	13.46 (9.82-17.17)	53.35 (36.35-116.12)
<i>Bemisia tabaci</i>	Eggs (>3 days old)	5.71 (3.93-7.50)	22.61 (15.45-47.73)
<i>Bemisia tabaci</i>	Scales	4.56 (3.59-5.44)	21.34 (16.31-32.64)
<i>Liriomyza huidobrensis</i>	Larvae	10.36 (8.25-12.10)	21.24 (16.74-39.93)
<i>Liriomyza huidobrensis</i>	Eggs	18.52 (14.62-22.40)	79.73 (56.17-152.50)
<i>Liriomyza huidobrensis</i>	Pupae	8.04 (4.33-11.98)	91.01 (41.24-930.5)
<i>Myzus persicae</i>	Adults	7.58 (5.38-9.92)	32.4 (19.68-133.96)

Data are from fumigations carried out using initial concentrations of 2 g.l<sup>-1</sup> of phosphine.

Table 2: Maximum CTPs (mg.l<sup>-1</sup>h) and durations (hours) of phosphine fumigation, survived by a range of plant pests

Species	Stage	Maximum CTP (duration) survived
<i>Bemisia tabaci</i>	Eggs	17.24 (8)
<i>Bemisia tabaci</i>	Scales	10.72 (6) for eggs > 3 days old 10.72 (6)
<i>Liriomyza huidobrensis</i>	Larvae	17.24 (8)
<i>Liriomyza huidobrensis</i>	Eggs	40.2 (24)
<i>Myzus persicae</i>	Adults	23.38 (17)

## References

- C. Hawkes, (1973) Assessment of phosphine fumigation as a plant quarantine measure against *Spodoptera littoralis*. *Ann. appl. Biol.* **75**, 393-399.
- O. C. Macdonald and K. A. Mills, (1994) Plant Quarantine Treatments: Are there Alternatives to Methyl Bromide? *Brighton Crop Protection Conference - Pests and Diseases* 1994. 1, 183-190.